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# eMedication Meets eHealth with the Electronic Medication Management Assistant (eMMA)

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**Abstract.** *Background:* A patient's healthcare team is often missing a complete overview on the prescribed and dispensed medication. This is due to an inconsistent information flow between the different actors of the healthcare system. Often, only the patient himself knows exactly which drugs he is actually taking. *Objectives:* Our objective is to exploit different eHealth technologies available or planned in Switzerland to improve the information flow of the medication data among the stakeholder and to support the patient in managing his medication.*Methods:* This work is embedded in the "Hospital of the Future Live" project, involving 16 companies and 6 hospitals in order to develop IT solutions for future optimized health care processes. A comprehensive set of requirements was collected from the different actors and project partners. Further, specifications of the available or planned eHealth infrastructure were reviewed to integrate relevant technologies into a coherent concept. *Results:* We developed a concept that combines the medication list and an eHealth platform. The resulting electronic medication management assistant (eMMA) designed for the patient provides the current medication plan at any time and supports by providing relevant information through a conversational user interface. *Conclusion:* In Switzerland, we still need a bridging technology to combine the medication information from the electronic patient record with the medication plan's associated QR-Code. The developed app is intended to provide such bridge and demonstrates the usefulness of the eMediplan. It enables the patient to have all data regarding his medication on his personal mobile phone and he can - if necessary - provide the current medication to the health professional.

**Keywords.** EHealth, Electronic Prescription, Medication Safety, Medication System, Conversational UI, mHealth

## 1. Introduction

Adverse drug events and patient harm is often caused by errors in the medication process such as overdosing, drug-drug-interactions, or contraindications [1]. Information systems and clinical decision support systems provide means to avoid such medication errors by automatic checks and availability of all relevant information [2,3]. Even though technical means are in principle available, a challenge in many countries is still the information transfer on prescribed and dispensed medications among several healthcare providers [4]. Consider the example of our fictional patient, Elisabeth Brönnimann, a 78 years old woman, who gets prescriptions from her general practitioner, by her orthopaedic specialist, and by her specialist in pulmonology. From time to time, she is

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going to the pharmacy directly and buys additional drugs. When she is going to the hospital for a hip implant, she receives yet another medication. All these prescriptions and dispensings are documented in different information systems leading to fragmented health information [5,6]. To avoid this fragmentation, many European countries try to establish eHealth strategies, aiming at providing an accurate, current medication list of a patient [7]. With the various eHealth strategies adopted in Germany, Austria and Switzerland in recent years, digitalization in the health care system is on its way. In Switzerland, a Federal Law on the Electronic Patient Dossier [8] entered into force at the beginning of 2017. By 2020, all hospitals are expected to have an implementation of the Electronic Patient Dossier (EPD). The Swiss eHealth strategy was adopted by the Federal Council in 2007. It targets at making all data relevant for a treatment accessible to the health care professionals. An interdisciplinary group of professional associations (IPAG) developed the technical content for a national exchange format for eMedication [7]. An interim solution is to generate a paper-based medication list which can be digitised by a QR-Code and is then updated by the doctor and pharmacist when necessary [9].

In particular with regard to a digital implementation including a connection to an eHealth platform, there are still numerous open questions. In this paper, we examine the question: How can a digital medication plan be linked to an eHealth platform, to make sure that all health care providers can benefit from digitization, even if not all the prerequisites for eHealth are currently met? We developed a concept and a prototype of a mobile app that address this question.

## 2. Current Drug Prescription Process in Switzerland

To demonstrate the current situation of drug prescription in Switzerland, consider the following example (see Figure 1).

1. An elderly person with rheumatic ailments makes an appointment with his rheumatologist at the hospital.
2. The rheumatologist measures the blood pressure and recognises an increased blood pressure. For this reason, he prescribes on the one hand a medication to lower the blood pressure and on the other another hand, a drug to reduce the rheumatic ailments.
3. After the visit at the hospital, the patient has to make a routine examination with his family doctor.
4. The family doctor measures the blood pressure and recognises an increased blood pressure as well. The patient forgets to mention to the doctor that he is already taking blood pressure lowering medication. Instead, the doctor makes another prescription.
5. At the pharmacy, the patient would like to get the second medication for the blood pressure. They recognise the double prescription and refuse to provide both prescriptions.
6. Because of his current health situation, the patient suffers from a depression. For this reason, the pharmacist dispenses St. John's wort. However, the patient forgets to mention that he takes TNF-Alpha-blockers. Consequently, as a side effect of St. John's wort consumption, the effectiveness of TNF-Alpha-blockers is reduced in the patient.

7. For this reason, the pain of the rheumatic ailments returns and the patient has to return to the hospital.

The main reason for this or similar problems is the inconsistent information flow among the physicians and the healthcare team. In addition, there is no direct communication between the different actors in the healthcare system. Instead, the patient has to carry and provide the relevant information which is an additional burden for a patient and leads to information loss as in the scenario described before.

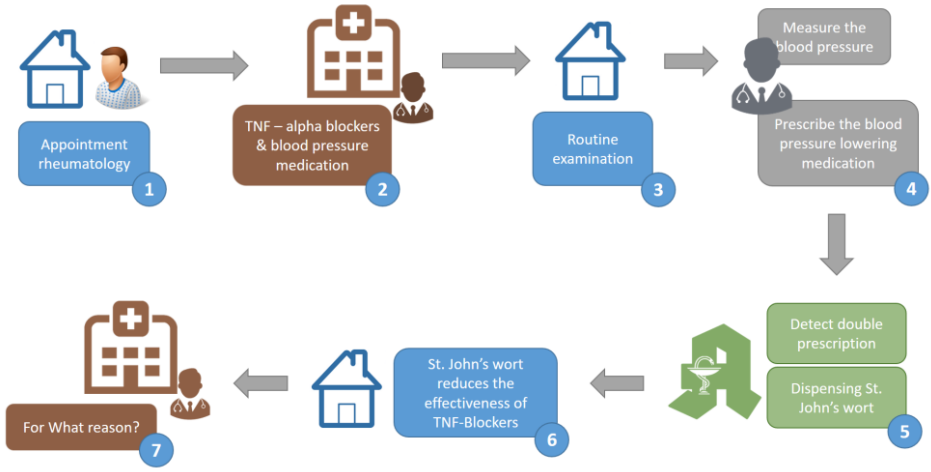


**Figure 1**. Current situation in drug prescription: Information drug prescription and dispensing is not integrated leading to side effects in the patient

## 3. Methods

Our concept and prototype development was realized in three steps: 1) requirements analysis, 2) concept development and 3) prototype implementation.

This work is embedded in the "Hospital of the Future Live" project, involving 16 companies and 6 hospitals in order to develop IT solutions for future optimized health care processes taking into account eHealth technologies [10]. For this reason, we were applying a multi-stakeholder principle: requirements were collected from the different actors by E-Mail and interviews and integrated into a coherent concept. More specifically, we asked physicians for a description of the current situation and ideas on possible improvements. In addition, relevant literature was assessed for collecting requirements. In the following, we are describing the infrastructure in Switzerland and the available technology that has been selected for realising our concept.

### *3.1. eMedication and eMediplan in Switzerland*

Within the Swiss eHealth strategy, standards and processes are specified among others for eMedication. More specifically, according to the interprofessional working group eMedication in Switzerland (IPAG), eDocuments with medication information are going to be exchanged between various healthcare providers in future [8]. IPAG specified a first draft of an exchange format for eMedication in 2016 [11] consisting of four main elements: 1) eCurrentMedication, 2) ePrescription, 3) eDispense and 4)

eMedicationComment [11]. Another achievement of the eHealth strategy is the introduction of the Electronic Patient Dossier (EPD). In contrast to hospitals that are obliged to exploit an EPD in future, the ambulant sector in the Swiss healthcare sector will not follow within the same timeframe and will continue working with paper documents. The Swiss software provider HCI Solutions (http://www.hcisolutions.ch/de/) who is distributing information platforms and software related to medication, developed an eMediplan [9] as a bridging technology. A community of interest, IG eMediplan (http://emediplan.ch), was founded to coordinate and maintain the introduction of the eMediplan by an independent association. The eMediplan can be generated and printed from the information entered into an information system on medication, allergies and risk factors. A QR-Code shown on the printed document allows to import the data to another information system. This enables health professionals to upload the eMediplan to the EPD. The eMediplan is using the same data structure as used for the eMedication [8].

### *3.2. Conversational User Interfaces*

Conversational User Interfaces provide text and language based interactions between user and system [13]. The idea originates from the immense use of text messaging systems such as WhatsApp or Telegram by persons of many age groups. Thus, the idea is to exploit language based chatbots to reduce the complexity of user interfaces and in this way to simulate a communication is similar to human conversations. Chatbots have already been used for providing diabetes control / management to patients [12]. However, this type of interface design is relatively new and thus experiences in the health care domain are still limited.

## 4. Results

From the interviews, we collected the requirements and objectives towards our concept and system. The system should:

- reduce double prescription and medication misuse,
- reduce contraindications and medication errors,
- make relevant, current information on the medication available at any time for health professionals and the patient,
- provide access to compliance data regarding drug consumption for health professionals.

In the following, we are introducing the developed concept and are describing the prototype implementation of the mobile application eMMA.

### *4.1. Concept*

Our concept integrates the EPD with an eMediplan and the mobile app eMMA to provide a solution for all relevant stakeholders including the patient and to make the medication information available to all involved persons. eMMA retrieves the current medication from the eHealth platform and can generate an eMediplan which in turn can be imported

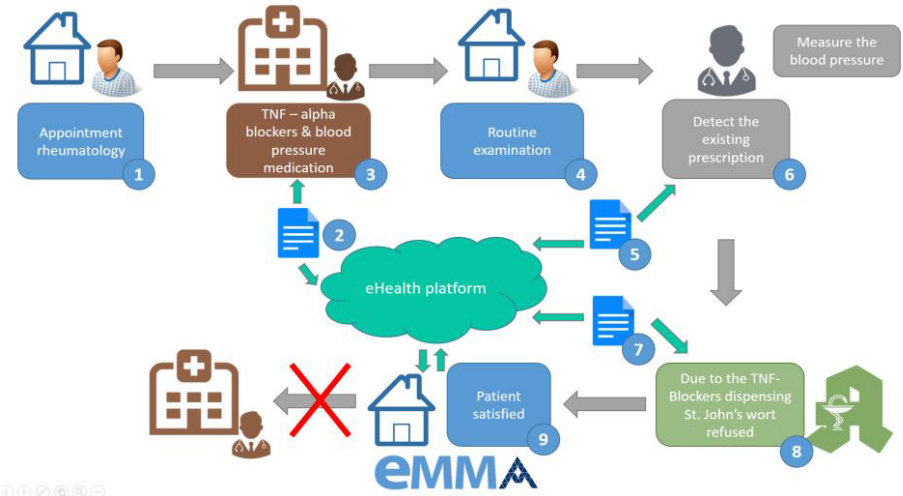


**Figure 2**. Future situation with eMMA and eMediPlan: Relevant information is stored in the eHealth platform and can be accessed on demand.

by the health professional through scanning of the QR-Code [9]. The patient always has his current medication plan available through this app. Furthermore, the app can exchange all data with an eHealth platform. In addition to the digitization of the drug plan, the app also provides essential functions for the safe use of medications. Among others, an active substance register and an interaction check are integrated. The patient is additionally reminded of the medication intake and can give feedback on his health status. The app has an intuitive user interface and additionally a Conversational User Interface [13] for interaction with the system.

Figure 2 shows the scenario when implementing our concept: The eHealth platform is in the middle of the care process. Whenever medication information is required or new information is added, the current data is collected from the platform or the data on the platform is updated. In this way, double prescriptions and possible drug-interaction are recognized in time and can be avoided.

Further, the patient can communicate with the application. For example, because of dizziness, the patient decides to not take the blood pressure lowering medication. He uses the app eMMA with the conversational user interface and mentions that he did not took the medication because of the recognized symptoms. Such compliance data provided in the conversation with the app is stored in the eHealth platform and the physicians can access this data on demand. Furthermore, the patient receives reminders from the eMMA app to take his medicine. With an access rights management, the patient can decide who is allowed to access his stored data. In addition, the patient can check for interactions of his current medication with food and can – if necessary – adapt his lifestyle.

### *4.2. eMMA App*

The functionalities of the app eMMA have been described already in the previous section. We are focussing now on the data flow (see Figure 3). After the successful login, the app will check for updated medication information on the electronic patient record (1). If an updated eMedication exists on the platform, the corresponding data is downloaded, transmitted as HL7 CDA CH MTPS [14] and stored on the database of the application

by applying the same structure as the eMediplan. If the patient has a more recent version of his medication on a paper-based eMediplan, he can scan the QR-Code and in this way, import the data from the paper. (2) The app is collecting and (3) storing locally the agents for each drug from the medication plan using an agent database such as the compendium (https://compendium.ch/). (4) The application checks for interaction for each active substance by querying a knowledge base and (5) stores the information again locally. Then, (6) the patient communicates with the app over a conversational user interface [13]. Through this interface, the patient can ask the app specific questions about his current medication. (7) For interpreting the user input and to produce realistic answers, the application is connected to a semantic server. A possible question could be on interactions, or on the dosage. (8) As an additional feature, the patient can take a picture of his medication. The application will make a request to the identification database (9) to retrieve the name of the drug. This allows to add easily additional drugs that are not yet listed on the eMediplan [9]. (10) The interaction with the system, in particular the conversations regarding the drug consumption are stored in the eHealth platform. Later, the doctor can easily access this data and monitor whether the patient takes regularly his drugs or whether he needs additional guidance.

The drug-interaction check aims not at providing all medication interaction to a patient for his current medication. This would overwhelm the patient who is often lacking the background knowledge for a correct interpretation and judgement of the actual risks. Instead, a subset of interactions is extracted, namely information on food interaction of the current medication, which is then provided to the patient. Checking for drug-drug interactions remains in the hand of the prescribing health professional.

Figure 4 shows an example interaction of the patient with the conversational UI. At the bottom of the screen, there are the different options for an answer. This enables the patient to have a fast and easy way to communicate with the app without the need of entering words or even sentences.

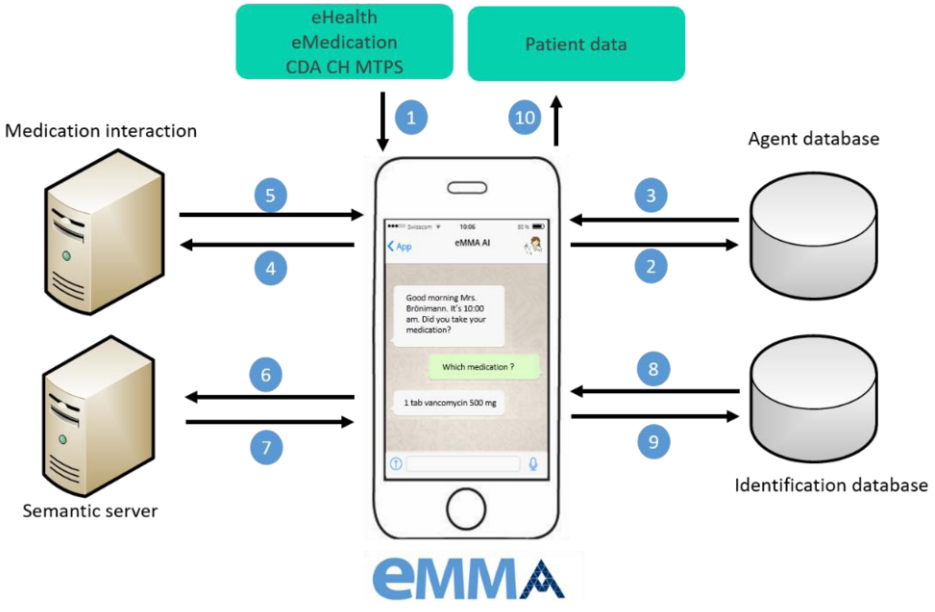


**Figure 3.** Concept of the mobile application data exchange between external services.

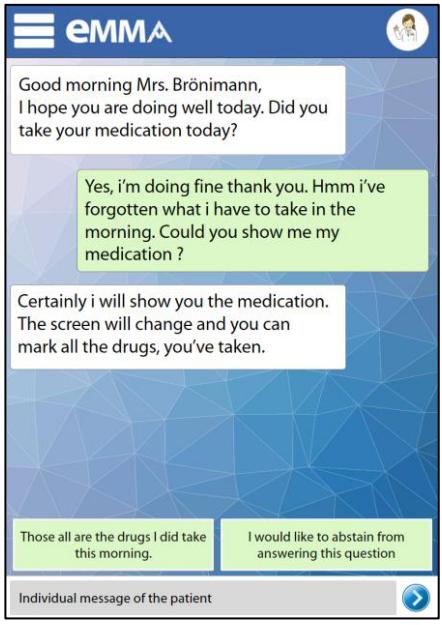


**Figure 4.** Interaction with eMMA through the conversational user interface

## 5. Discussion

Our concept is based on the assumption that an EPD will be implemented in Switzerland in the near future. Changes in the health care system due to the introduction of the EPD in all hospitals will be available only in a few years [8]. As long as the EPD is not yet realized, the eMediplan will be used as main data source for the app. How far the distribution of the eMediplan could be supported by our solution still needs to be considered. In any case, the outpatient physicians have to be motivated to use the EPD by demonstrating benefits. The eMediplan in combination with our concept could be a first motivating step. To the best of our knowledge, there is no mobile application currently available that enables a process as described in this work. It provides a mean to make the current medication data of a patient available.

Even though the law for the introduction of the EPD [8] currently does not make it obligatory to document a patient's self-medication, it is clear that such information can be important to avoid contraindications. By providing additional functionalities such as a reminder or checks for food interactions, an additional benefit for the patient is created. Through the conversational UI, a patient can be motivated in taking his medication regularly, relevant information can be provided and compliance data can be collected [13]. This provides him with more responsibilities and leads to patient empowerment. Preliminary tests with the prototype showed that CUI could provide a good mean for the interaction in this context. However, a comprehensive usability study still needs to verify this. The responsibility for the complete drug interaction will still be in the hands of the physicians or the pharmacists because the patient has not the competence to fully understand and judge all possible interactions. Further, functionalities of the application have to be evaluated and integrated into the final version. Also, legal aspects need to be taken into account. The stored data about the compliance of the patient should not be

used to harm him. For example, the cost of a rehospitalisation cannot be shifted to the patient only because he did not take his medication regularly.

Another important feature of our app will be the improved medication adherence for the patient achieved through electronic reminders. Recent studies have shown ambivalent results with respect to an improvement of the adherence through electronic reminders. While some studies demonstrated an improvement of the medication safety with reminders [15],other studies could not verify an improvement for the adherence [16]. Therefore, we decided to design our app not only as a reminder. Through a conversation with the application, a bond of trust will be created. To enable this, all interactions will be designed in a way that the patient feels safe about the information he receives from the application. Only in this way, we can ensure that he is willing to take all the medications the app is recommending him and that the adherence information he implied is correct. Future studies with our app will show if this concept is realistic and accepted from patients.

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